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ABSTRACT

This report presents a broad overview of the research and opinions of experts in the field of educational computing, in order to provide information for educators concerning the implementation of microcomputers in education. The document primarily consists of annotations of articles reviewed, which are grouped in five categories. The first section introduces some of the trends in education resulting from the computer revolution and discusses changes that are presently occurring or will soon occur in education. Computer awareness and aspects for consideration in within-school computer use are then addressed. The third section highlights the implementation process, along with its problems, potentials, and the need for more research. Attitudes of teachers and others toward computers in the classroom are examined in the fourth section. The final section deals with computer assisted instruction (CAI), including problems and potentials of CAI, problems in evaluation of CAI materials, and research on CAI effectiveness. A summary, conclusions, recommendations, and a 62-item bibliography are included. An appendix presents an illustration of an implementation, followed by data tables displaying information on program use and nonuse, the impact of instructional aids on examination scores, the effectiveness of lectures versus CAI, and variables addressed by CAI research. Figures display data on CAI studies and other data included in 10 major studies. (LMM)

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IMPLEMENTATION OF MICROCOMPUTERS IN THE CLASSROOM:
PROBLEMS AND POTENTIALS

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INTRODUCTION

As a result of the introduction of microcomputers into all aspects of society, there has been an increased demand on public education to provide students with computer education so that students who graduate will be computer literate and capable of functioning in a society that is being changed by computer technology. In order to make effective use of computers within the classroom, educators must become acquainted with research in the field of computer technology and its applications in the classroom.

Although knowledge of research in the field is important, it is not enough. In order to help students become computer literate and prepare them for the changing society, educators are going to need to become computer literate as well. They will need to be taught about computers and their functions before they can incorporate them in their own classrooms.

Some areas that educators should possess a knowledge and understanding of are "the capabilities, uses, and limitations of computers." (Grady and Poirot:79) The competencies required for teachers should include a knowledge of the following: computer systems, computer terms, educational uses, history of computers and calculating, problem-solving techniques, nonschool uses, and relationships between society and computers. (Grady and Poirot:79)

STATEMENT OF THE PROBLEM

Because microcomputers have become available at lower prices in the past few years, many schools have begun to develop computer labs and have begun to offer educators the opportunity to supplement traditional teaching methods with the computer. This computer-assisted instruction (CAI), although widely accepted by some educators, is viewed by others with skepticism. The reasons for skepticism are numerous, but the fact that the computer age has dawned seems to indicate that educators must adapt to these changes soon. This study dealt with reasons for the skepticism of classroom computers and examined the problems, potentials, and effectiveness of implementing microcomputers in the classroom.

PURPOSE OF THE STUDY

The purpose of this study was to review the research and the opinions of experts in the field of computer technology in education to disclose to educators the problems and potentials of implementing microcomputers in education. It was hoped that a better understanding of the problems and potentials involved in computer-assisted education would alleviate skepticism on the part of many educators and allow them to become aware and receptive of the potentials, as well as the limitations, of the microcomputer.

ORGANIZATION OF THE STUDY

Because there is considerable difficulty in finding articles which give only one side of the issue of computer

use in the classroom, the annotations are likely to contain a little of each despite their placement. The reason for their placement in one category as opposed to another is due to the amount of material or importance of the material under that specific heading.

The first section introduces some of the trends in education resulting from the computer revolution and discusses changes that are presently occurring or will soon occur in education. The second section deals with the idea of computer awareness. Included are various aspects that need to be considered in computer use within the schools. A third section highlights the implementation process along with its problems, potentials, and need for more research. The fourth section includes attitudes of teachers and others toward computers in the classroom. The fifth and last section deals with computer-assisted instruction. This section includes problems and potentials of CAI, the problems involved in evaluating CAI materials, and research on the effectiveness of CAI.

The annotations within each heading have been arranged to follow a logical developmental order, and when this was not possible are in alphabetical order.

LIMITATIONS OF THE STUDY

Despite the fact that microcomputers are relatively new, an abundance of material has been written about them. Because of time constraints and the many aspects involved in computer use in education, this study represents a broad

overview of the research and opinions concerning computer-assisted instruction, rather than focusing on the many other aspects of computers in education.

GLOSSARY

BASIC -- "An acronym for Beginners All Purpose Symbolic Instruction Code. A high level conversational, interpretive, programming language in wide use. Always written in capital letters, BASIC was invented by Kemeny and Kurtz at Dartmouth College in 1963."

(Douglas and Edwards:120)

branching -- "A place in the program where a choice is made to depart from the normal sequence of program instructions."

(Douglas and Edwards:120)

character -- "Single items that can be arranged in groups to stand for information. There are two forms: (1) numbers, letters, graphic symbols, etc., that can be understood by human beings, and (2) groups of binary digits that can be understood by the computer. A character is usually represented by one byte." (Douglas and Edwards:121)

computer -- "A device that receives and then follows instructions to manipulate information. The set of instructions and the information on which the instructions operate are usually varied from one moment to another. ...The difference between a computer and a programmable calculator is that the computer can manipulate text and numbers; the calculator can manipulate only numbers."

(Douglas and Edwards:122)

computer aided guidance -- techniques for helping and guiding users in trouble. (Alty:4)

computer-assisted instruction (CAI) -- "refers to the teaching and learning which occur during interactions between teachers and students, supported by course materials and computers." (Stevens and Sybouts:83)

computer-based instruction (CBI) -- applications are divided into two functions. Direct instructional use is called CAI and instructional management use is called CMI. (Milner, 1980:13)

computer literacy -- "that collection of skills, knowledge, understanding, values and relationships that allows a person to function comfortably as a productive citizen of a computer-oriented society." (Watt:105)

computer-managed instruction (CMI) -- "can be used to diagnose, retrieve resources and information, test, evaluate and store information." (Stevens and Sybouts:84)

computer science -- deals with the technical content, teaches students to write programs using various programming languages. (Stevens and Sybouts:82)

courseware -- "A combination of content, instructional design, and the software which causes a computer to implement instruction." (Douglas and Edwards:122)

graphics -- "Characters that can be used to form figures, shapes, and forms on the CRT or printer. In addition to letters and numbers, a computer may have a graphic character set so arranged that they can be combined to form almost any desired figure." (Douglas and Edwards:124)

hardware -- "Mechanical, magnetic, electrical, and electronic devices which make up a computer. The physical equipment that goes into a computer system, consisting of the central processing unit plus all peripherals."

(Douglas and Edwards:124)

languages -- "A format by which a programmer can communicate more efficiently with a computer where predetermined commands will yield requested actions....A language is a defined group of representative characters or symbols, combined with specific rules necessary for their interpretation. The rules enable the assembler or compiler to translate the characters into forms... meaningful to a machine, system, or a process."

(Douglas and Edwards:126)

MECC --- Minnesota Educational Computing Consortium formed in the early 1970's to meet the demand for educational computing. "The consortium brings together under a joint powers agreement four public education systems: the University of Minnesota, the State University System, the Community College System, and the State Department of Education (representing Minnesota's 433 public school districts)." (Rawitsch:453)

memory -- store programs and data either by Random access (temporary) Memory (RAM) or by Read only (permanent) Memory (ROM). (Frederick:17)

microcomputer -- "Microcomputers include the same functional components as larger computer systems...But microcomputers cost less...use fewer languages, and have less memory." (Milner, 1980:12)

MINNIE -- prototype of the portable, personal teaching computers developed at the National Physical Laboratory in England. (Evans, 1981:5)

peripheral -- "A device, such as a printer, mass storage unit, or keyboard, which is an accessory to a microprocessor and which transfers information to and from the microprocessor." (Douglas and Edwards:128)

programs -- "A series of instructions to a computer which cause the computer to solve a problem or perform a task." (Douglas and Edwards:128)

software -- "Refers to programs and accompanying documentation. Software is stored on tape cassettes or discs when not being used by the computer. The computer reads the software into its memory in order to use the programs." (Douglas and Edwards:129)

ANNOTATIONS

CURRENT TRENDS IN EDUCATION AS A RESULT OF COMPUTER TECHNOLOGY

"School Microcomputers Triple Since 1980, NCES Survey Shows,"
Phi Delta Kappan 64:294, December, 1982.

The National Center for Education Statistics (NCES) reported that the number of microcomputers had tripled since 1980 while the number of computer terminals remained relatively constant. The survey showed that 29,000 of the 82,000 public schools in the U.S. had at least one computer, and 80 percent had microcomputers only. The availability of the computers varied by grade level with most of the computers being in the secondary schools. Primary uses for the computers included teaching computer science, developing computer literacy, and teaching basic skills. Good educational courseware was indicated as being the major need by 60 percent of the schools.

Evans, Christopher, "An Invitation to the (Near) Future,"
Today's Education 71:12-15, April/May, 1982.

Evans saw the microcomputer as being the second wave of the highly advanced computer technology that will lead to changes and advances in the teaching process. The development of the pocket teaching computer is not far away, and it will bring with it a sweep through education. Evans stated that the value of the computer lay in how it can teach, not in what it teaches. The teaching profession will react to this part-threat and part-challenge at a differential rate, with a kind of elitism, and eventually developers of programs will prepare highly motivational materials.

Gleason, Gerald T., "Microcomputers in Education: The State of the Art," Educational Technology 21:7-18, March, 1981.

Gleason toured four institutions well known in computer technology in 1980-81 to study the state of instructional technology and, more specifically, computer-assisted instruction (CAI) and microcomputer applications. Most of the article contained Gleason's perspectives on the state of the art after having conducted his study. He found that there is widespread acquisition of microcomputers due to reduced costs and availability of software. Gleason felt that computer literacy courses need to be instituted for teachers and the general public, and they need to be required for prospective teachers. According to Gleason, computer use has become both a process and a tool for investigating the process.

Grady, M. Tim, "Issues and Implications," in Computers in Curriculum and Instruction, pp. 160-162, edited by M. Tim Grady and Jane D. Gawronski, Association for Supervision and Curriculum Development, 1983, 173 pp.

Grady highlighted five issues that must be faced in the future as movement is made toward a computer literate society. Those five issues can be summarized as follows: Teachers must become literate; leadership from outside sources must be provided so that teachers have examples to follow of how to integrate CAI with traditional curricula; more meaningful research must be done on the effects of CAI and computer-managed instruction (CMI) on student achievement and attitudes as well as the effective presentation on computer-based curricula; educators must be aware of hardware obsolescence and plan for the future; and finally a positive attitude toward the computer as an information system in the schools must be established.

Lewis, Anne C., "OTA Report Supports Federal Intervention to Bring Informational Technology to U.S. Schools," Phi Delta Kappan 64:155-156, November, 1982.

The Office of Technology Assessment (OTA) conducted a two-year study called "Informational Technology and Its Impact on American Education." Information specialists, school superintendents, and prominent educators worked on the report. The report stated that economic and social survival is dependent upon adoption through education. The OTA supported some type of federal intervention to spur schools into faster and more thorough computer development or implementation. Options available included tax incentives for equipment in schools, subsidies for software development, direct funding of school hardware and software purchases, and the elimination of unintentional regulatory barriers.

Long, Sandra M., "The Dawning of the Computer Age: An Interview with Ronald Palamara," Phi Delta Kappan 63:311-313, January, 1982.

Most of Long's article concentrated on how computers would affect education, although other questions dealing with work force, home computers, and changing lifestyles outside of education were discussed. Long conducted her interview with a former educator, now computer specialist, to find his views on computers in education. Palamara saw the role of education being to improve learning and having the obligation to experiment with whatever new technologies become available. He stated that the goals for preparation of students for a computerized revolution should start early before biases and fears can form, and the computer should be a tool within schools.

Melmed, Arthur S., "Information Technology for U.S. Schools," Phi Delta Kappan 63:308-311, January, 1982.

New demands are being placed on education as a result of technological developments already at work in the industrial and business areas stated Melmed. The new information technology has created new educational needs and also inexpensive ways to meet those needs. Hardware prices have declined, but the critical missing ingredient is the lack of availability and lack of good quality software. A large market such as a school could stimulate the development of good courseware. Three conditions could delay full use of computers in the classroom for twenty years: money available for instructional materials, current inventory of courseware, and current investment in developing new approaches to student use of computers. Melmed supported a long period of expensive development coming from the nonprofit sector, federal government, and private foundations.

Pipho, Chris, "The High-Technology Bandwagon Starts to Roll," Phi Delta Kappan 64:85-86, October, 1982.

Pipho indicated the challenge technology has given the U.S. educational institutions, and he posed two important questions about schools and technology. One concerned whether or not schools and colleges were being faced with a mission without adequate funding, and the other dealt with the possibility of entering a new period of public support for education. As a member of the Governors' Task Force on informational technology, Governor Jerry Brown stated that schools must augment the three R's with the three C's of computing, calculating, and communications. In his article Pipho cited the Institute for Educational Research's viewpoint that the training of teachers and administrators is the key to microcomputer implementation.

Shane, Harold G., "The Silicon Age and Education," Phi Delta Kappan 63:303-308, January, 1982.

The primary concern of Shane was the implications of the computer revolution for education. After giving the background of computer development, Shane discussed the influence of microcomputers on schooling, education, and learning as he defined each of these categories. Shane cautioned teachers to avoid feeling threatened and proposed that they should try to anticipate the far reaching effects the microcomputer will have. Despite the fact that computers will make drastic changes, Shane did not see changes occurring very rapidly in schools for about five years. Reasons cited for the slow implementation were budgets, teacher resistance, and the development of suitable software.

Winkle, Linda Wyrick, and Matthews, Walter M., "Computer Equity Comes of Age," Phi Delta Kappan 63:314-315, January, 1982.

Two computer revolutions have occurred; the first one transformed society and the second one is transforming education stated the authors. According to Winkle and Matthews, consideration must be given to the question of equal access to computer literacy for each person. Special attention must be given to females and their use of computers since math and computers have tended to be considered a male domain. To make sure that females also become involved with computers, the authors stated that an equity plan must be installed no later than the ninth grade, if not sooner. Three steps that elementary principals should take to prevent computer anxiety and promote computer equity included enhancing the self-concept of girls toward computers, providing computer literacy as a survival skill in the elementary school, and enhancing computer equity through expanded career goals for girls.

COMPUTER AWARENESS

Identification of Terminology and Components

Frederick, Franz J., "Inside Microcomputers," Today's Education 71:16-19, April/May, 1982.

Frederick briefly introduced the terminology involved with the use of microcomputers. He included definitions for such items as the central processing unit; Memories, RAM and ROM; the clock, the bus; interfaces; power supply; chip; appliance; floppy diskette; disk drives; and program languages, such as BASIC, Pascal, FORTRAN, LOGO, and COBOL.

Huntington, John F., "Microcomputers and Computer-Assisted Instruction," Educational Technology 19:32-37, May, 1979.

Huntington observed the use of the TRS-80 microcomputer and discussed its uses and limitations in learning about BASIC and CAI. He looked at each aspect of the computer to indicate what was necessary for making a good CAI program and discussed the capabilities and problems. The aspects of the TRS-80 that were observed were the Memory, peripheral storage, generating student records abilities, display characters, and the special graphics dictionary. Limitations of Level 1-BASIC were answer analysis, CAI coding examples, and scoring.

Questions to Ponder

Robinson, Sharon P., "Questions for Teachers," Today's Education 71:27-28, April/May, 1982.

Robinson concerned herself mainly with questions that teachers should ask themselves about using microcomputers. She viewed the computer as raising questions about teaching and learning. Some of the questions teachers should ask themselves dealt with how the technology will be used and how the role of the classroom teacher will change. Because the future could depend on the teacher's ability to put children above the machine, the teachers must master the new technology and know its strengths and weaknesses.

Uhlig, George E., "Electronic Education: Dimensions and Directions," Education 103:106-111, Winter, 1982.

Uhlig cited John H. Gibbons' conclusions on the impact of the information revolution on society. From there he pondered three important questions. He wondered where the development of technology is heading, how rapidly it will continue, and what its impact might be for the teaching and learning process. He differentiated between computer awareness and computer literacy citing that computer awareness involves the School Board, parents, and citizens; whereas, computer literacy involves teachers, administrators, teacher-educators, and students. Uhlig concluded that the potential of the microcomputer in the areas of education, propaganda, communications, and learning may be even more powerful than TV.

Dealing with Staff Development

Cohen, Michael R., "Improving Teachers' Conceptions of Computer-Assisted Instruction," Educational Technology 19:32, July, 1979.

Forty-four teachers were asked to draw a picture of the computer they were going to use, include themselves in the picture, and list educational uses of the computer prior to using a PLATO instructional computer. Results showed that teachers drew pictures of computers of ten years ago. Cohen stated that instruction on using the computer in the classroom must begin from the teacher's viewpoint at that time. The more important issue, however, is the teacher's conception of the educational uses of the computer. Computers do much more than teachers can do. The teachers' concepts must be changed and myths thrown aside, clarified, and understood so that preconceived notions do not prohibit or limit CAI.

Copple, Christine, Computers in the Secondary Mathematics Curriculum, Educational Resources Information Center, ED 204 144, June, 1981.

Copple's paper had as its purpose to increase the educator's awareness of computer use in the classroom. Although her paper was directed at math, she included broader aspects of computer such as the present situation of computers, CAI advantages and disadvantages, and the advantages and disadvantages of teaching computer literacy and computer science. Most of Copple's paper was an annotated bibliography concerned with the items mentioned above.

Lovell, Paulette, "Staff Development for Computer Literacy," Educational Technology 23:18-19, March, 1983.

Because many schools have purchased and implemented microcomputers for the purpose of enhancing curriculum and developing computer literacy, staff development has become a critical issue. Lovell outlined a six-step process of change for staff development in computer literacy. The basic outline included choosing a manager, defining goals, researching the topic, consulting with those who change easily, designing working models to allow teachers to work with computers, and designing a delivery system.

COMPUTER IMPLEMENTATION

How and Why Implement?

Oliver, Clarence, G., Jr., "Directions, Difficulties of the First 'Byte'," NASSP Bulletin 66:1-5, September, 1982.

Oliver stated that leading a district to use computers as educational tools requires planning as well as salesmanship. Emphasis should be placed on the fact that computers are supplemental classroom tools, not replacements for teachers. After discussing budget concerns, equipment, and uses of the computer, Oliver concluded by citing two barriers to classroom implementation of computers. These two barriers were the need for teachers trained in computer literacy and use and the need for more instructional programs. He further concluded that microcomputers are important features in the future classroom where personalized learning, individualized situations, feedback, patience, and attention-capturing screen displays help learners move at their own pace.

Stevens, Dorothy Jo, and Sybouts, Ward, "Computers in the Classroom," The Clearing House 56:82-85, October, 1982.

The purpose of this article was to summarize information from experienced teachers to answer three sets of questions about microcomputers in the classroom. Stevens and Sybouts stated that determining the instructional purpose for which the computer was to be used was the most important step to be made. Educators must also know the approach to instruction that they want. The authors briefly discussed these approaches: Computer Science, Computer Literacy, Computer-Assisted Instruction, and Computer-Managed Instruction. Organization patterns discussed as applicable for microcomputers were learning resource centers, station concept, media centers, and computer labs.

Smelser, E. Keith, "Microcomputers: Fad or Function?" in Microcomputers in the Schools, pp. 94-95, edited by James L. Thomas, Oryx Press, 1981, 158 pp.

Smelser viewed the microcomputer as a device that will bring significant impact to education. Although it will be resisted by some teachers, outside forces will force consideration of their use. Smelser concluded by offering guidelines for accepting and implementing microcomputers.

Examples of Successful Implementation Plans

Ebersole, Gerri Noonan, "Electronic Carrots," Today's Education 71:24-26, April/May, 1982.

In 1978 Ebersole and Lee Decker set up a team teaching program in math and science at Gompers Secondary Center in San Diego for Grades 7-12. Classes were divided into two groups, and the computer was used to reinforce lessons in three ways: drill and practice, simulation, and program writing. The two-year sequence program of Math/Science/Calculator and Math/Science/Computer was established and proved quite successful. Some students from the program have written programs sold worldwide, and others have become employed in helping others use the computer and in writing programs for different fields.

Gusé, GeorgeAnn M., "Computers in the Classroom: An Incentive for Teachers," NASSP Bulletin 66:12-17, September, 1982.

Gusé supplied a circular graph to illustrate the ten steps Broken Arrow High School made in two years toward computerization. [See Appendix A for graph.] The outer circle represented gradual and recommended movement toward district growth, and the inner circle represented progressive stages. Each of the steps was outlined and described in detail by the author.

Levin, Dan, "In This System, the Computer Future is Now," The American School Board Journal 169:27-28, March, 1982.

Levin reported on the comprehensive plan of computer education established by John Bristol, a superintendent in Lyons Township high school district in LaGrange and Western Springs, Illinois, who set a goal of universal computer literacy for his staff and students. Bristol approached the computer program in a logical and systematic way. Before he decided on the type of microcomputer to buy, he and his staff set objectives for the use of the machines in their district. Inservice programs were scheduled for staff members to get the program under way.

Brumbaugh, Kenneth E., "MECC: A Statewide Model for Educational Computing," in Computers in Curriculum and Instruction, pp. 64-73, edited by M. Tim Grady and Jane D. Gawronski, Association for Supervision and Curriculum Development, 1983, 173 pp.

Brumbaugh discussed how the Minnesota Educational Computing Consortium (MECC) was started in 1973 and the different divisions which are part of the MECC. Each of the advisory structures had its own jobs, and these were discussed. The MECC recently purchased microcomputers and compared timesharing systems with the microcomputer systems. Also MECC has a courseware development program and has conducted research in the use of CAI.

Hausmann, Kevin, "Statewide Educational Computing Systems: The Many Considerations," in Microcomputers in the Schools, pp. 17-19, edited by James L. Thomas, Gryx Press, 1981, 158 pp.

Hausmann described MECC's efforts to acquire and implement educational microcomputers on a statewide basis.

- Rawitsch, Don G., "Implanting the Computer in the Classroom: Minnesota's Successful Statewide Program," Phi Delta Kappan 62:453-454, February, 1981.

Rawitsch discussed how Minnesota successfully implemented the computer in the classroom on a statewide level. He stressed that computers must be implemented through constant and specialized support that requires time, money, and energy and dedication on the part of educators. Because computers are thinking machines that help learners do more, individualize learning, and parents will demand them in the schools, they can become durable classroom innovations. The formation, training, and funding of the MECC were discussed. Rawitsch concluded by stating that effective support for computers in instruction must come from within education.

- Gull, Randall L., "A Successful Transition from Mini- to Microcomputer-Assisted Instruction: The Norfolk Experience," Educational Technology 20:41-42, December, 1980.

Gull highlighted the transitions made by his school corporation from the mini-computer to the microcomputer. Since 1975 CAI played an important and productive part in instruction within the Norfolk Public Schools. That all came to a standstill in 1978 when the minicomputer being used reached its operating capacity. In the article Gull detailed the steps taken to remedy the situation and the subsequent purchase of microcomputers. The dilemma concerning owning hardware that software would not work on caused a great deal of frustration, but that problem was worked out.

Barriers to Implementation

- Dean, Jay W., "What's Holding Up the Show?" Today's Education 71:20-23, April/May, 1982.

Dean cited two limitations on the ability of teachers to use computers effectively in the classroom. The first limitation is the lack of useful programs. Included in this limitation were the fact that some programs fail to account for the knowledge of the learning process; some are the product of teachers who are lacking in technical aspects needed to effectively use the computer; and finally, developers of software are fearful of sending programs out for evaluation since they might easily be duplicated. The second limitation is the lack of a computer language that teachers can use to create or adopt software suitable for their own classes. In other words, a language that is easy to learn and use, resembles natural dialogue, and allows for variation in style has not been developed.

Grady, M. Tim, and Poirot, James L., "Teacher Competence: What is Needed," in Computers in Curriculum and Instruction, pp. 78-82, edited by M. Tim Grady and Jane D. Gawronski, Association for Supervision and Curriculum Development, 1983, 173 pp.

The authors were concerned with dealing with the problem of teacher computer literacy, and they provided a list of required competencies that most of the educational communities should possess. At the end of the article, the authors provided definitions of these competencies.

Grossnickle, Donald R., and others, "Profile of Change in Education: A High School Faculty Adopts/Rejects Microcomputers," Educational Technology 22:17-19, June, 1982.

A status report on the use of microcomputers in Palatine High School, a Chicago suburban secondary school, was based on 74 completed questionnaires which had been distributed to 153 faculty members. The study revealed that a small percentage of the faculty used computers. Eight of the twelve departments did not even have a single respondent using the microcomputer. The authors believed that a substantial number of the faculty may have offered such excuses as lack of time, training, and available software to rationalize their lack of desire for change. The study also indicated that some departments lacked information on how to use the microcomputer in their subject area.

Milner, Stuart D., "Teaching Teachers About Computers: A Necessity for Education," in Microcomputers in the Schools, pp. 108-111, edited by James L. Thomas, Oryx Press, 1981, 158 pp.

Milner stated that teachers are not required to study computer education in order to teach in most states; they fail to know about or know how to use computer-related materials effectively; it is a low priority item in relation to other areas; and there is a reluctance to study computer science despite a recognition of the need for computer training. Milner offered guidelines for thinking about and planning for teacher training. He also suggested changes that need to occur for teachers in instructional design, designing computer-based learning materials, programming, hardware and software organization, and uses of computers in education and in society.

Watt, Daniel H., "Computer Literacy: What Should Schools Be Doing About It?" in Microcomputers in the Schools, pp. 104-107, edited by James L. Thomas, Gryx Press, 1981, 158 pp.

Watt defined computer literacy as the "collection of skills, knowledge, understandings, values and relationships that allows a person to function comfortably as a productive citizen of a computer-oriented society." (p. 105) He then divided the definition or concept into five categories. Watt felt that schools should continually expand and revise computer literacy objectives for the next few years. Computer equity could become a problem if rural and inner-city schools fail to implement computers for student use and if females remain stereotyped. Watt concluded that time and money were two considerations involved in staff development for computer literacy.

Sheingold, Karen, and others, Study of Issues Related to Implementation of Computer Technology in Schools, Final Report, Educational Resources Information Center, ED 210 034, National Inst. of Education (DHEW), Washington, D.C., July, 1981.

This study of three school districts with a diversity of applications of microcomputers at the elementary and secondary levels was completed to discover and identify how microcomputers were being used and the issues surrounding implementation. The research team interviewed and observed to acquire information about microcomputers in the schools. Six trends that were discovered from the study were differential access to microcomputers, emergence of new roles in response to microcomputers, lack of integrating microcomputers into elementary classes and curriculum, inadequate quantity and quality of software, inadequate preparation of teachers in using microcomputers, and a lack of knowledge of effects and outcomes.

Zucker, Andrew A., "The Computer in the School: A Case Study," Phi Delta Kappan 63:317-319, January, 1982.

Zucker's case study was concerned with Milton Academy in Massachusetts. He stated that the computer there was used in three ways: courses, extracurricular activities, and administrative tasks. Zucker reminded his reader that computers are not panaceas and not without problems. Some problems noted were attaining and keeping qualified staff, obtaining resources available for staff development, and expenses beyond the cost of the computers themselves.

Moursund, David, "Microcomputers Will Not Solve the Computers-in-Education Problem," in Microcomputers in the Schools, pp. 112-116, edited by James L. Thomas, Oryx Press, 1981, 158 pp.

Moursund contended that the use of microcomputers in education has solved some problems but created others. One goal of microcomputers included having students understand how to use the computers as tools in any discipline. Another goal dealt with CAI, and a third concerned itself with more advanced instruction. Barriers to accomplishing these goals included the lack of sufficient and adequate hardware, lack of appropriate software and courseware, lack of adequately trained teachers and administrators, and a lack of support from school board, parents, and taxpayers. As a result of the microcomputer, the first and last barriers have been lifted.

Evans, Christopher, "Bringing the Computer into Education," Media and Methods 17:4-5,9,18, April, 1981.

The three reasons for the difficulty in bringing computers into the classroom stated by Evans were that no one knew what the best teaching methods were; although people knew little about the educational process, they thought they did and they thought it was simple; and there was little evidence that large sums of money were to be made in teaching, human or automatic. Evans spent much of his time in discussing the MINNIE portable, personal teaching computer.

McDonald, David, and Gibson, Karen, "The Rural School District and the Microcomputer," NASSP Bulletin 66:75-77, September, 1982.

This case study approach was taken by the authors to acquaint readers with problems faced by the West Franklin School District in implementing computers in the classroom. Equipment that had previously been purchased and not used was placed in a central location. Additional equipment was purchased. Problems that had to be dealt with were obtaining adequate service on hardware, failures of machines, and hoarding of the equipment by the few who knew how to use it. The problems were solved and a program of inservice and staff development was instituted to familiarize teachers with computer care and usage. Inservice was also designed to relieve anxiety and apprehension.

Sturdevant, Rosemary, "Microcomputers and Copyright in Education," Phi Delta Kappan 63:316-317, January, 1982.

Sturdevant tried to clear up some of the copyright features of computer software. The 1976 Copyright Act was amended in 1980, and two changes were made. One change defined programs as literary works. The other change occurred in Section 117 which was rewritten to allow an owner to make a copy of his program for archival purposes or for using the program out of necessity. If the program is sold or given away, the copy must be destroyed. Although fair use can be made of the programs, educators cannot copy the programs. Educators must be aware of the copyright laws governing these computer programs.

Potentials of Implementation

Eisele, James E., "Classroom Use of Microcomputers," Educational Technology 19:13-15, October, 1979.

Schools should realize the mood of the times is based on computer technology, and it is time to make use of microcomputers in the classroom. This article discussed new ways the computer can be used in the classroom, such as teaching computing to all students, using the computer as a problem-solving tool, and using challenging and entertaining games. Adaptations to existing uses like drill and practice, simulation, and tests and test construction were included. Guidelines for accomplishing what educators ought to do were also mentioned.

Miller, Inabeth, "The Micros Are Coming," in Microcomputers in the Schools, pp. 90-93, edited by James L. Thomas, Oryx Press, 1981, 158 pp.

Parents have demanded microcomputers enter education. The potential of microcomputers to act as classroom managers for teachers has arrived according to Miller. They can be used for drill and testing, games and simulations, and individualized pacing of curriculum. The problems involved with microcomputers as seen by this author were software and the changing technology. Miller stated that now is the time to learn and act because the computer has the potential for humanizing education and for opening up teaching and learning opportunities through the classroom teacher.

Zakariya, Sally Banks, "The Computer Goes to School," Principal 61:16-20, 52-54, May, 1982.

The purpose of the Wingspread Conference on Microcomputers in Education was to evaluate the role of the microcomputers in education at the elementary and middle levels. Those attending the conference included computer experts, curriculum specialists, and principals. Zakariya highlighted such things as the advantages of the microcomputer: potential as interactive teaching tool, personal and intellectual skill development, procedural thinking, eye-hand coordination, small-muscle development, and entertaining and motivating. The immediate consequences of using microcomputers as stated were the changes in teachers' roles as imparters of information to mentors and guides. Instructional computers can involve teaching with or about computers. Problems mentioned were the lack of good quality software and good evaluation and selection of software.

Comras, Jay, and Zerowin, Jeffrey, "The Computer as a Positive Learning Experience," NASSP Bulletin 66:18-21, September, 1982.

Comras and Zerowin perceived a "noticeable lack of progress in the application of computer technology to the learning process." (p. 18) Part of the problem is due to the fact that available software is not keeping up with hardware development. One problem associated with CAI implementation is the indiscriminate purchase of software. The authors cited Instructor magazine's survey to determine how schools use computers. Results showed most use them for drill and practice; few use them for problem solving, testing, or managing instruction. The authors contended that the capabilities of the microcomputer in teaching cognitive skills goes beyond giving out information and providing drill and practice. Programs can have self-pacing devices, branching capabilities, and management systems which can teach students how to think and make cognitive applications to new problems.

Hunter, Beverly; Seidel, Robert J; and Hargan, Carol, Assessing the Impact, Benefits, Limitations, and Costs of Computer Innovations in Education: A Retrospective Case Study Approach, Educational Resources Information Center, ED 208 852, National Science Foundation, Washington, D.C., February, 1979.

The overall objective of this case study was to provide a qualitative assessment of the impact, benefits, limits, and costs of computer-based innovations in education. The authors felt the assessment might help school personnel in making decisions about computers.

Kinds of Research Still Needed

"Editor's Note: What We Still Need to Know," in Computers in Curriculum and Instruction, pp. 19-20, edited by M. Tim Grady and Jane D. Gawronski, Association for Supervision and Curriculum Development, 1983, 173 pp.

This article posed five areas of research questions whose answers could provide educational communities with knowledge to plan and implement a computer-based curriculum. The five areas of research were motivation, graphics, educational validity, timing, and games.

Collis, Betty, "Questions for Research on Microcomputers as Instructional Media," Educational Technology 23:43-44, March, 1983.

Collis called for empirical, controlled research that deals with the cognitive effects of the microcomputer instead of the descriptive case studies or details of particular instructional units which had been used. She concerned herself with raising questions which she felt needed to be answered for students and teachers. Collis also distinguished between using computers as tools and using them as objects of study. Her questions were based on both of these uses of the microcomputer.

Alty, J. L., "The Impact of Microtechnology: A Case for Reassessing the Roles of Computers in Learning," Computers and Education 6:1-5, 1982.

Alty reviewed advances in microtechnology, such as cost and flexibility, that have affected CAI and CAL. He discussed the wider effect on the computing environment and concluded that the number of computer users will result in a spread of users who do not have the knowledge about computers. Therefore, it will be necessary for systems to provide computer aided guidance to help and guide users in trouble.

ATTITUDES TOWARD COMPUTERS IN THE CLASSROOM

Teacher Attitudes

"Computers? You Bet I'm Interested!" Instructor 91:76-77, May, 1982.

Four thousand readers of Instructor responded to a teacher attitude survey on computers in the October, 1981, issue. Results showed that teachers were interested, open-minded, and ready to learn how to make use of computers more effectively. The survey set aside the myth that the teachers new to the classroom were more receptive to the computers than more experienced teachers. It also disproved that microcomputers will never be accepted in the elementary grades.

Joiner, Lee Marvin; Miller, Sidney R.; and Silverstein, Burton J., "Potentials and Limits of Computers in Schools," Educational Leadership 37:498-501, March, 1980.

Because vendors of computers have exaggerated the claims of what computers can do, some teachers assume a defensive attitude toward computer use fearing they will be replaced by the computer. These fears are exaggerated since successful use of the computer as teacher depends on many human variables. There is also a limit to how much time students can spend working on computers beneficially. Advantages cited by the authors included reduced learning time, useful management tool, useful school business manager, useful manager of diagnostic and prescriptive information, easy access to hardware, increasing availability of software, and a language that is easy to learn. Weaknesses included lack of CAI languages for microcomputer applications, limited ability to perform repetitive calculations, limited ability to store and recall language files, and limited courseware.

Martellaro, Helena C., "Why Don't They Adopt Us?" Creative Computing 6:104-105, September, 1980.

Martellaro was concerned about the potential that computers offer for classrooms and the insufficient number of students exposed to the computer. She cited as a reason for the lack of exposure the fact that schools tend to resist change. A combination of traditional attitudes and wariness of innovations affected attitudes toward computers. Martellaro cited three types of teachers of which most fit into the type of teacher who believes microcomputers have potential but are fearful of them in the classroom.

Billings, Karen, "Microcomputers in Education: Now and in the Future," in Microcomputers in the Schools, pp. 87-89, edited by James L. Thomas, Oryx Press, 1981, 158 pp.

This article discussed the recent interest among school personnel to provide students access to computer technology due to the recent marketing of microprocessor-based games and word processing machines. Billings acknowledged that not all teachers would make use of classroom computers because of their 1984 image, faddishness, or bothersomeness. She stated that teachers' roles will change, but teachers will not be replaced. Student attitudes toward the computers have been favorable and less fearful than teachers. Teachers must know how they want computers used within their own classroom. Some problems of microcomputer technology included the lack of appropriate instructional programs and the lack of information about what is being done in education.

Pitts, Mark, "Straight Talk About Microcomputers," School and Community 68:18-19,34, April, 1982.

Salesmen claim microcomputers are the answer to all learning problems; educators complain about their inadequacies. Pitts attempted to set readers straight about microcomputers. He stated that one must approach the purchase of microcomputers with adequate knowledge and realism. Pitts identified five aspects of consideration in purchasing the microcomputer. Those aspects included how computers are to be used, information about manufacturers, price, availability of quality software, and cost justification. Pitts stated that microcomputers can increase interest, are individualized and personal, and allow students to gain experience on a tool other occupations use.

Geisert, Gene, "How to Help Teachers Welcome Computers," The American School Board Journal 169:29, March, 1982.

The main thrust of this article by Geisert was to make sure that implementation of computers be done at a rate that failed to alarm teachers who might view them as a potential substitute. Even though everyone did not agree on the value of microcomputers, many educators saw their use as helpful to teachers and administrators in doing their jobs more quickly and effectively. Others argued that microcomputers helped students learn. Another focus of the article was on reassuring teachers that microcomputers could be a blessing rather than a threat. He asserted that teachers who have used computerized instruction felt their students spent their time more effectively, were less disruptive, and scored higher on state minimum competency tests and national standardized achievement tests.

Other Attitudes

"Getting Started with Microcomputers," Instructional Innovator
25:10-11, September, 1980.

The author indicated that microcomputers are not perfect, can not solve all problems, and are not easy to operate. The greatest value of the microcomputer is in admitting the user to the age of technology. Advice was given to people who have ignored microcomputers, dismissed them as playthings, rejected them after failures at using them, and those eager to purchase them. The author stated that learning how to operate a microcomputer is a learning process that is time consuming and frustrating. Prices of these computers range from \$500 to \$5000 and are decreasing. Just because they are fun does not mean they are not helpful educational tools was the author's viewpoint.

Magidson, Errol M., "One More Time: CAI is Not Dehumanizing,"
Audiovisual Instruction 22:20-21, October, 1977.

Magidson elaborated on the societal contention that computers are dehumanizing. He viewed the concern as being distorted and inaccurate, and he substantiated his statement with seven points to answer the dehumanizing criticism. Magidson contended that the dehumanizing criticism was a way of rationalizing the concern teachers have that CAI might replace them. Although he agreed that some tasks handled by teachers could be given over to the computers, he believed that this would free the teacher and allow more time for socialization through greater interpersonal communication and small-group work. CAI should be used to supplement traditional methods. In conclusion Magidson stated that a variety of approaches to instruction should be employed to stimulate active student involvement.

Levin, Dan, "Microcomputers: Out of the Toy Chest and into the Classroom," in Microcomputers in the Schools, pp. 101-103, edited by James L. Thomas, Oryx Press, 1981, 158 pp.

Levin stated that the impact of microcomputers will be felt by everyone in the 1980's. Although there is worry about obsolescence and cost, now is the time to implement according to Levin. Changes will continue to occur in software more than in hardware. Levin warned his reader not to make the mistake of waiting for the perfect microcomputer. Despite the pitfalls of lack of teacher training and poor software, microcomputers should be implemented. They can provide tools for teaching, but they will not replace teachers.

COMPUTER-ASSISTED INSTRUCTION

Problems and Potentials

Feurzeig, W., and others, Microcomputers in Education, Report No. 4798, Educational Resources Information Center, ED 208 901, National Inst. of Education (DHEW), Washington, D.C., October, 1981.

The authors reviewed briefly the history of CAI methods and indicated that what was learned on mainframes and mini-computers can be applied to microcomputers. The authors also cited prominent evaluations on the educational effectiveness of CAI. They discussed the educational promise of microcomputers as being the study of computers, the study of programming as a mental discipline, and the integration of computers into the classrooms of different subject areas.

Caldwell, Robert M., "Improving Learning Strategies with Computer-Based Education," Theory into Practice 19: 141-143, Spring, 1980.

The instructional capabilities or potentials of computers include the provision of interactive instruction, provision of alternative learning paths, independent pacing, controlled reinforcement, quick evaluation, and the storage of massive amounts of information about the student. Caldwell noted that the computer offers a new tool for "developing a range of cognitive learning strategies." (p.142) He felt that research should be conducted to investigate the effects of dialogue and simulation in computer-based programs on movement of learners through learning development stages. Courseware must "help students access information in a way that contributes to meaningful learning patterns." (p.143)

Holmes, Glyn, "Computer-Assisted Instruction: A Discussion of Some of the Issues for Would-Be Implementors," Educational Technology 22:7-13, September, 1982.

Holmes stated as some of his reasons for implementation of computer-assisted instruction the potential for individualized learning, more interaction, tutoring, the diagnosis of deficiencies, and the effectiveness of leading to some student achievement and motivation. Also in the article, Holmes discussed his concern with such major problems as cost, choice of system or hardware, people and attitudes, curriculum, and courseware.

Magidson, Errol M., "Issue Overview: Trends in Computer-Assisted Instruction," Educational Technology 18:5-8, April, 1978.

CAI has the ability to individualize and personalize the instructional process and to stimulate experiences which learners might not have available to them stated the author. CAI can be used as texts, tests, and tutors. It can compel active participation at the learner's own rate, give him feedback, and the student can have variable control over his learning. Magidson expected that the computer usage would increase inside and outside of education. He included results of studies done by Kulik and Jaska (1977) that showed CAI was at least as effective if not more effective than traditional instruction. Most CAI usage supplemented traditional instruction, not replaced it. Also cited was the 1977 Human Resources Research Organization (HumRRO) publication identifying 350 American schools, colleges, and universities that had used CAI effectively.

Milner, Stuart D., "How to Make the Right Decisions About Microcomputers," Instructional Innovator 25:12-19, September, 1980.

Milner introduced his reader to the microcomputer by identifying the different components. He then discussed the two applicable functions of computer-based instruction (CBI): CAI and CMI. The benefits of CBI fell into two categories. One was instruction improvement and enhancement factors, and the other was cost-effectiveness factors. A further breakdown of these factors followed. Milner provided several descriptions of microcomputers being used at the time. Some of the warnings that Milner listed about using CBI were that CBI had its limitations, could be expensive, might not always work under certain conditions, and required time for adjustment and acceptance.

Stakenas, Robert G., and Kaufman, Roger, "Technology in Education: Its Human Potential," The Education Digest 47:15-18, March, 1982.

Stakenas and Kaufman defined educational technology and restated four notable achievements that research and development in educational technology produced. Also mentioned and discussed were the seven lessons learned about educational technology. These lessons were that it could teach content as well as traditional education; it designed and produced high quality instructional media systems; it radically changed curriculum decision-making; it changed the role of teaching personnel; planning capabilities to implement were often lacking; it shifted the focus to what learners were to accomplish; and social support mechanisms were needed to be built into systems.

Stewart, L. R., "Here's What Classroom Computers Can Do,"
The American School Board Journal 169:32,45, March,
 1982.

Stewart focused entirely on a sampling of the capabilities of the microcomputers in the classroom situations. Several possibilities for using the microcomputer were mentioned within each of the subject areas as well as in teacher record keeping and central office management.

Schwartz, Marc D., "Integrating Computer-Assisted and Videotaped Instruction," Educational Technology 20: 36-37, August, 1980.

The advantages of combining microcomputers and videotapes for teaching were discussed. Schwartz talked about how CAI and videotapes could be integrated to set up a teaching program. Such an integration would increase the teaching value of thousands of available teaching videotapes.

Smeltzer, Dennis K., "The Media Specialist and the Computer: An Analysis of a Profession's Attitude Towards a New Technology," in Microcomputers in the Schools, pp. 96-100, edited by James L. Thomas, Gryx Press, 1981, 158 pp.

Smeltzer observed the increasing use of microcomputers in the classroom will result in the growing need for media specialists to provide support services since the computer specialists lack educational background or experience in providing expertise in designing and developing instructional systems. In this article Smeltzer discussed his survey of media specialists. Results showed media specialists had had little training in computer technology. They tended to recognize and accept computer influence on lives, but a minority viewed this influence negatively. Although capable of error, the computer was viewed to play the role of a tool to assist in problem solving.

Problems of Courseware Evaluation

Golas, Katharine C., "The Formative Evaluation of Computer-Assisted Instruction," Educational Technology 23:26-28, January, 1983.

Golas based her article on the following definition of formative evaluation: "the process of collecting empirical data during the development of instructional materials to ascertain if they need revision." (p. 26) She was concerned mainly with the formative evaluation of CAI since none existed. Her purpose was to describe special considerations that should be accounted for by evaluators of CAI. Golas outlined a recommended approach for conducting a CAI formative evaluation. Special consideration must be given to the hardware "downtime," evaluation of student performance, and the experience or inexperience of working with the computer.

Steffin, Sherwin A., "A Suggested Model for Establishing the Validity of Computer-Assisted Instructional Materials," Educational Technology 23:20-22, January, 1983.

Steffin delineated the problems involved in the evaluation of CAI materials. He then outlined a suggested procedure of continuing research implemented by Edu-Ware Service, Inc., based on output objectives identified as being necessary to comprehensive assessment models. Steffin identified the steps taken in the research which he hoped would be a continuing process.

Steinberg, Esther R., "Reviewing the Instructional Effectiveness of Computer Courseware," Educational Technology 23:17-19, January, 1983.

Steinberg discussed the review of the instructional effectiveness of courseware. Those aspects already considered in courseware reviews included administration, implementation, and instruction. Steinberg proposed three additional categories to the review process. The three categories were the stability of the lesson for users, the quality of implementation and unique CAI features, and the observations of users. Steinberg also believed that courseware should be reviewed by a person from the content area and by a person who knows the features of CAI.

Is CAI Effective?

Cavin, Claudia S.; Cavin, E. D.; and Iagowski, J. J., "The Use of Computer-Assisted Instruction to Provide Optional Assistance to Students," Educational Technology 19:42-45, June, 1979.

In 1978 the authors tested six CAI programs designed for tutorial assistance in a general chemistry lab course at the University of Texas, Austin. Their purpose in conducting the study was to examine some aspects of student use of the programs, and special interest was centered on determining the extent to which students voluntarily used CAI programs, examination of individual interactions with the programs, attitudes toward the programs, and reasons for not choosing them. At the end of the course, users and nonusers turned in questionnaires. Findings indicated that users had favorable attitudes toward the programs. Many felt the programs were helpful and often enjoyable. Problems appeared to be limited access, dislike of working with computers, and easier access to other helpful sources. [See Appendix B for reasons for not doing a program.]

Gershman, Janis, and Sakamoto, Evannah, "Computer-Assisted Remediation and Evaluation: A CAI Project for Ontario Secondary Schools," Educational Technology 21:40-43, March, 1981.

The Computer-Assisted Remediation and Evaluation (CARE) project carried out by the Ontario Institute for Studies in Education (OSIE) covered a two-year time period from 1978 to 1980. It had as one of its purposes to create and evaluate CAI sequences for intermediate math in grades 7-10. Of 2000 students from 20 schools, 1082 were CARE students, and the others were the informal comparison group. Test scores in 1979 showed no difference. Scores in 1980 showed CARE students improved significantly more than non-CARE students at the same school. Evaluations by students and teachers about attitudes toward CARE were surveyed and found to be favorable. Advantages cited were individualization, motivation, and student pacing.

Gadzella, Bernadette M. "Computer-Assisted Instruction on Study Skills," Journal of Experimental Education 50: 122-126, 1981-82.

An experimental/control group design of research to determine the effectiveness of the CAI study skills program on student behaviors and attitudes as measured by a study skills inventory was conducted by Gadzella. The 88 experimental students and 67 control students each responded to a Survey of Study Habits and Attitudes inventory test three times. Results varified the hypothesis stated by Gadzella that significant differences between groups would be expected. The results showed that the experimental group gained greater insights on effective study skills and attitudes in comparison to the downward shifts in the control group.

Hoffman, Jeffrey L., and Waters, Keigh, "Some Effects of Student Personality on Success with Computer-Assisted Instruction," Educational Technology 22:20-21, March, 1982.

The purpose of this experiment conducted at the Naval Technical Training Center in Pensacola, Florida, was to see if significant relationships existed among personality types and student performances in a self-paced CAI program. The Myer-Briggs Type Indicator (MBTI) was selected to assess individual personality preferences. The MBTI was administered to each member of each incoming class for seven weeks. Comparisons were based on demographic variables which came from the Armed Services Vocational Aptitude Battery (ASVAB) scores and MBTI indices. It appeared that certain dimensions of personality can affect completion rate of a training program if it is completed at all. Sensing types completed the program, but extroverts, intuitives, and perceiving types had high rates of attrition. CAI seemed to favor people who have the ability to concentrate, attend to details, have an affinity for memorizing facts, and can stay at the task until it is completed.

Dwyer, Thomas A., and Critchfield, Margot, "Multi-Computer Systems for the Support of Inventive Learning," Computers and Education 6:7-12, 1982.

Dwyer's article described preliminary work in the development of a multi-microcomputer environment in which students used simulations to stimulate inventive learning. Dwyer noted that one of the greatest challenges teachers face is that of helping students experience inventive learning. Such learning requires supportive social environments and supportive physical environments which the microcomputer may be capable of providing.

Burns, Hugh L, and Culp, George H., "Stimulating Invention in English Composition Through Computer-Assisted Instruction," Educational Technology 20:5-10, August, 1980.

Burns and Culp conducted a research study at the University of Texas, Austin, on the effects of CAI in stimulating invention in English composition. In 1977 research began when a pilot study was completed to validate the heuristic question pools. In the pilot study, researchers found a significant difference in the quantity of ideas between pretest and posttest. Students in four English composition classes were randomly assigned to classes, and each group was presented two one-hour lectures on heuristic strategy. Both developmental and research findings were mentioned. One important research finding was that the three experimental groups differed significantly from the control groups with respect to the number of ideas generated, comprehension of those ideas, insightfulness, factuality, and more. Burns and Culp concluded that stimulation of invention in English composition via CAI is possible, quantitatively and qualitatively effective, and individualized.

Soldan, Ted, Evaluation of Three Microcomputer Teaching Modules, Educational Resources Information Center, ED 223 468, National Science Foundation, Washington, D.C., April, 1, 1982.

The experiments performed by Soldan examined questions about the effectiveness of CAI. Soldan wanted to find out whether microcomputer modules could teach effectively and whether they enhanced learning when supplemented to the traditional methods. Results showed that learning was achieved to a high degree of significance, but CAI supplemented to the conventional teaching methods did not significantly improve learning. However, Soldan did feel that microcomputers deserve a place in education, and they have increasing potential.

Skinner, Steven J., and Grimm, Jim L., "Computer-Assisted Instruction Case Study: The Introductory Marketing Course," Educational Technology 19:34-36, July, 1979.

The authors conducted a case study to research the effects of CAI on an introductory marketing class of 125 students. Students were divided into four groups: CAI, study guide, both CAI and study guide, neither CAI or study guide. Three exams were given during the semester, and comparisons of the scores on these exams were made to determine any differences among the four groups. Data showed that Tutorial Review of Marketing Principles (TRMP) users scored significantly higher than those using no instructional aid, and they also scored higher than those using the study guide. Students using CAI showed favorable reaction. The authors concluded that CAI was effective in increasing learning probably because of active participation. They also concluded that CAI was a viable learning device in marketing. [See Appendix C for Impact of Instruction Aids on Exam Scores Table.]

Paden, Donald W.; Dalgaard, Bruce R.; and Barr, Michael D., "A Decade of Computer-Assisted Instruction," The Journal of Economic Education 9:14-20, Fall, 1977.

This three-year study was based on CAI in economics at the University of Illinois. The three parts of the study were a study management system; CAI testing, seminar, student tutors program, and instructional sequences. Part one demonstrated that a study management system facilitated learning for the randomly assisted groups of students. Part two demonstrated that the study management system plus the exams given by the computer, seminars, and undergraduate tutors were an effective substitute for formal lectures and most discussion groups. Part three indicated that even though the computer transmitted content material as effectively as traditional means, performance was not significantly improved by doing so. The authors maintained that computers should be used to improve study habits, highlight concepts, process data, individualize instruction, give exams, provide feedback, keep records, and add pizzazz.

Chizmar, John F.; Hiebert, L. Dean; and McCarney, Bernard J.,
 "Assessing the Impact of an Instructional Innovation
 on Achievement Differentials: The Case of Computer-
 Assisted Instruction," The Journal of Economic Education
 9:42-46, Fall, 1977.

In this study, the "differential in mean TUCE [Test of Understanding in College Economics] scores between users and nonusers of CAI was decomposed into the effect due to CAI and the effect due to differences in student characteristics." (p. 42) The experiment was conducted in the fall of 1975 at the Illinois State University. Students were given the option of using CAI or not. The output measure employed to evaluate the CAI technology was student scores on Part 1, Form B of the nationally normed TUCE administered before and after. The analysis showed that the effect of CAI was negative but small. The users as a group performed a little better in relative terms on the TUCE but only because they had more ability measured by grade point average. Analysis also showed that students with more ability chose CAI.

Tsai, San-Yun W. and Pohl, Norval P., "Student Achievement in Computer Programming: Lecture vs. Computer-Aided Instruction," The Journal of Experimental Education 46:66-70, Winter, 1978.

Tsai and Pohl conducted this study to compare four measures of achievement on college students in a computer programming course by using three different learning situations: traditional lecture, CAI, and traditional lecture plus CAI. The measurement devices chosen for each of these situations consisted of hour quizzes, homework assignments, a term project, and a final exam. The analysis of variance was implemented and data revealed that significant differences at the .01 level occurred when achievement was measured by quiz scores and final exam scores. No significant differences occurred when achievement was measured by homework scores or term project scores. Tsai and Pohl contended that findings suggested that CAI teaching/learning environments are at least as effective if not more effective than conventional lecture formats in college programming classes. [See Appendix D for statistical information on results]

Tsai, San-Yun W., and Pohl, Norval F., "Computer-Assisted Instruction Augmented with Planned Teacher/Student Contacts," The Journal of Experimental Education 49: 120-126, Winter, 1980-81.

The authors conducted three separate experiments using five different learning environments to study the differences in student learning achievement and retention in a college statistics course. Two tests were given to students: an achievement test of multiple choice and problem solving questions and a retention test of multiple choice only. Results showed that students in a lecture/discussion environment and students in CAI had no differences in achievement or retention, which validated CAI as a teaching instrument. Results of the second experiment involving lecture/discussion and CAI plus teacher/student contacts revealed significant differences favoring CAI plus in achievement, but no difference in retention. A third experiment was conducted to isolate the plus factor. Achievement scores were higher with CAI or plus environments, like programmed texts plus contacts. The authors concluded that CAI worked best when measuring achievement by multiple choice questions, and plus worked best when measuring achievement by problems.

Billings, Karen, "Research on School Computing," in Computers in Curriculum and Instruction, pp. 12-18, edited by M. Tim Grady and Jane D. Gawronski, Association for Supervision and Curriculum Development, 1983, 173 pp.

Billings' article tied together research that had been done in the past ten years on CAI and its effectiveness. The areas of research looked at were general studies, problem solving, creativity and writing, action research, games, and implementation. Billings summarized research done in these areas and stated the positive potential in these areas. She speculated that more research is needed in other subject areas and at various grade levels.

Dence, Marie, "Toward Defining the Role of CAI: A Review," Educational Technology 20:50-54, November, 1980.

Dence stated that CAI was not being used as effectively as it might since educators were not familiar with its capabilities. She reviewed the research that had been done on CAI since 1960. Most of Dence's article consisted of the findings of researchers concerned with CAI's use in subject matter, type of CAI used, branching, student attitudes, feedback, individualization, CAI v. traditional instruction, time, retention, and student variables. Dence contended that research needs to continue in the clarification of the role of CAI. She stated that research should be done through meta-analysis or Aptitude Treatment Interactions. [See Appendix E for Variables Addressed by CAI Research chart.]

Edwards, Judith, and others, "How Effective is CAI?: A Review of the Research," Educational Leadership 33: 147-153, November, 1975.

After having reviewed research which had been previously conducted on CAI effectiveness, these authors concluded that normal instruction supplemented by CAI proved more effective than normal instruction alone. When CAI was substituted for traditional instruction, results were mixed. Some studies showed CAI students achieved more than non-CAI students, and some showed little or no difference. No mode of CAI was consistently more effective than another. In comparison to other non-traditional methods of instruction, CAI was shown to be as effective. It reduces time for learning, but there is some evidence that retention is not as good as for traditionally taught students. [See Appendix F for figures showing these studies.]

Kulik, James A.; Bangert, Robert L.; and Williams, George W., "Effects of Computer-Based Teaching on Secondary School Students," Journal of Educational Psychology 75:19-26, February, 1983.

This article used meta-analysis to bring separately published studies together to determine the effects of computer-based teaching on students in Grades 6-12. An analysis of the 51 studies showed that CBI raised students' scores on final exams from the 50th percentile to the 63rd percentile. CBI also raised scores on follow-up exams, but retention effects were not as clear. CBI also seemed to have a positive effect on attitudes toward computers and toward the courses. Learning time was reduced considerably for students who were instructed on computers.

Vinsonhaler, John F., and Bass, Ronald K., "A Summary of Ten Major Studies on CAI Drill and Practice," Educational Technology 12:29-32, July, 1972.

This summary involved the content areas of language arts and math. The three major criteria met were that all studies used drill and practice mode of CAI; all studies concerned methods for improving performance as measured by the standardized tests; and the basic experimental/control group design was used. Results showed positive differences from .1 to .4 of a school year in favor of CAI in language arts. Advantages in math resulted except in two cases. Conclusions drawn by the authors were that traditional instruction augmented by CAI was effective in drill and practice in language arts and math when measured by Stanford Achievement Tests for Mathematics and Language Arts and the Metropolitan Achievement Test. [See Appendix G for Studies Included in the Survey and Results.]

SUMMARY

Evans (1982) referred to microcomputers as the second wave of computer technology which will change and advance the teaching process. He is not alone in his assessment of computer technology and its affect on education. Shane, Long, Melmed, and Winkle all see the computer revolution as having an important impact on education.

Different aspects of computer awareness involve knowing terminology and components. Frederick introduced brief but relevant terminology for microcomputer use. Robinson and Uhlig were concerned about getting teachers to ask questions about the microcomputer and its use. They especially wanted teachers to ask questions about the role the microcomputer will play in the classroom and how technology will change the role of the teacher. Uhlig saw the impact of the microcomputer as being more powerful than television. While Lovell cited staff development as being a critical issue and outlined a six-step process of change for staff development, Cohen stated that teachers' conceptions of computers need to be changed, but the change must begin from the teachers' present viewpoints.

Several reasons exist for implementing microcomputers in the classroom. Oliver cited the importance of microcomputers in personalizing learning, individualizing situations, providing feedback, and patience. Ebersole showed that the use of microcomputers could be beneficial to students by

providing students with computer skills wanted by fields outside of education. Oliver also stated that computer implementation should be presented to teachers as supplemental devices and not replacement devices. Stevens and Sybouts insisted that educators need to know for what purpose and what approach computers will be used for before implementation can be carried out.

Successful implementation plans that have been established on the district level were cited by Gusé and Levin (1982). On the statewide level, MECC was discussed by Brumbaugh, Hausmann, and Rawitsch.

Barriers to implementation were cited by several authors. Dean and Milner (1981) discussed the lack of ability of teachers to use computers and computer-related materials effectively. Grossnickle stated that teachers lacked the desire to change as well as a lack of information on how to use computers in their subject areas. Sheingold et al., Moursund, and Miller stated that software and courseware availability and quality were largely inadequate. Moursund and Sheingold et al. also saw the lack of trained teachers as being a major problem in computer education. Zucker mentioned that problems faced by Milton Academy consisted of attaining and keeping qualified staff, obtaining resources for staff development, and expenses beyond computers themselves. Dean and Sturdevant cited the problem of duplication of programs and copyright laws necessarily being changed.

Despite these problems, computers can be potentially

effective and rewarding. Eisele stated that computers can be challenging and entertaining, and he was supported by Zakariya who saw them as being entertaining and motivational. Comras saw advantages of self-pacing, branching, and management in helping students think and use cognitive skills. Miller agreed with the individual pacing concept and also added the potential for computers to act as classroom managers.

Research is still necessary to provide educators with a better foundation on which to establish implementation. Collis stated a need for empirical, controlled research dealing with the cognitive effects of microcomputers, and Grady and Gawronski saw a need for more research in the areas of motivation, graphics, educational validity, timing, and games.

Various attitudes toward computers exist among teachers. Instructor magazine conducted a survey in 1981 and found that teachers were open-minded, interested, and eager to learn more about the effective use of microcomputers. Some teachers assume a defensive attitude fearing replacement according to Joiner et al. Martellaro cited three types of teachers: those who saw computers as dehumanizing; those who saw them as having potential, but were still fearful; and those who were eager to implement the new technology. Pitts stated that teachers complain about inadequacies, but Geisert said that teachers who had used computers in education felt the computers did the jobs of teachers and administrators more quickly and more effectively. Others cited by Geisert felt that students were less disruptive, and they did better on state minimum competency tests and

national standardized achievement tests. In the September, 1980 issue of Instructional Innovator, microcomputers were cited as not being perfect, but they did admit the user to the new age of technology.

Computer-Assisted Instruction has its advantages and disadvantages. Advantages cited by Feurzeig et al. were the study of computers, the study of programming as a mental discipline, and integration into the classroom. Caldwell cited interactive instruction, alternative learning paths, independent pacing, controlled reinforcement, quick evaluation, and storage of information on students as advantages of CAI. Holmes saw advantages in individual learning, interaction, tutoring, diagnosis of deficiencies, and achievement and motivation. Magidson (1978) agreed with these findings and added the ability to simulate experiences not available to students. A final potential discussed by Schwartz was combining computers with videotapes to upgrade the teaching value of videotapes.

Problems with courseware evaluation were cited by Golas, Steffin, and Steinberg. Golas felt a need for formative evaluation of CAI courseware. Steffin outlined a procedure of continuing research, and Steinberg felt the need to add as criteria for courseware evaluation the stability of courseware for a particular group, the quality of CAI features and how they are implemented, and observations of users.

Studies on attitudes and the effectiveness of CAI conducted by Cavin and Gershman revealed favorable responses

to the programs used. This favorable attitude was also found in Gadzella's study on study skills and attitudes. Hoffman's personality study revealed that CAI favored people who could concentrate, attend to details, and stay at a task until it was completed.

Studies in invention were conducted by Burns and Dwyer. Burns revealed that invention could be effectively stimulated via CAI. Dwyer's study showed that invention could be stimulated via microcomputers since they provide supportive social and supportive physical environments.

Soldan and Paden found in their studies that CAI did not significantly improve learning, and Chizmar's study resulted in a negative but small difference between users and nonusers. Positive results in achievement were found in studies conducted by Tsai and Gershman. Summaries of research by Billings (1983), Dence, Edwards et al., Kulik, and Vinsonhaler revealed potentials for CAI, especially when supplemented to traditional teaching situations.

CONCLUSIONS

There seems to be overwhelming agreement that micro-computers have arrived as a second part of the computer revolution, and they are changing education and society. Without a doubt, educators are going to have to adapt to these changes if they are to continue in their careers as educators. These changes involve becoming aware of the problems, potentials, uses, and effectiveness of computers so that they can be applied effectively and successfully in education.

Before educators can successfully implement computers in the classroom, they must first undergo staff training and become computer literate themselves. If teachers fail to adapt, they may be replaced by others who can adapt to the changing roles from imparters of information to mentors and guides. (Zakariya:19)

Most experts are in agreement that computers carry with them problems and potentials. Continuing research needs to be carried out to deal with these problems effectively. Two of the most important problems that exist in computer education are the lack of good quality software and courseware and the lack of adequate teacher training in computer use. Educators must become more involved in inservice programs and computer studies so that they are aware of computer uses and terminology. Educators must also become involved in the development of computer courseware and demand that programs of high educational quality are produced for the educational market.

Although attitudes toward computer implementation are varied, most educators must realize that the time to act has come as the computer technology keeps moving in on the educational field from the outside community. Most experts who have studied computer-assisted instruction agree that attitudes toward its use by students are quite favorable and even motivational. There is very little disagreement among experts in the field of CAI that the effects of CAI are at least as effective if not more effective than conventional instruction. With such favorable research, making use of computers in the classroom might not be a bad idea. It is certainly deserving of considerable attention by all educators.

RECOMMENDATIONS

It is recommended that:

1. Computer implementation occur at a slow and systematic pace to allow for teacher and student acceptance.
2. A high priority should be given to staff development by teachers, administrators, and the public.
3. Research be conducted in more areas and at various grade levels. (Billings, 1980:20)
4. Clarification of the role of CAI be conducted through meta-analysis or Aptitude Treatment Interactions.
(Dence:54)

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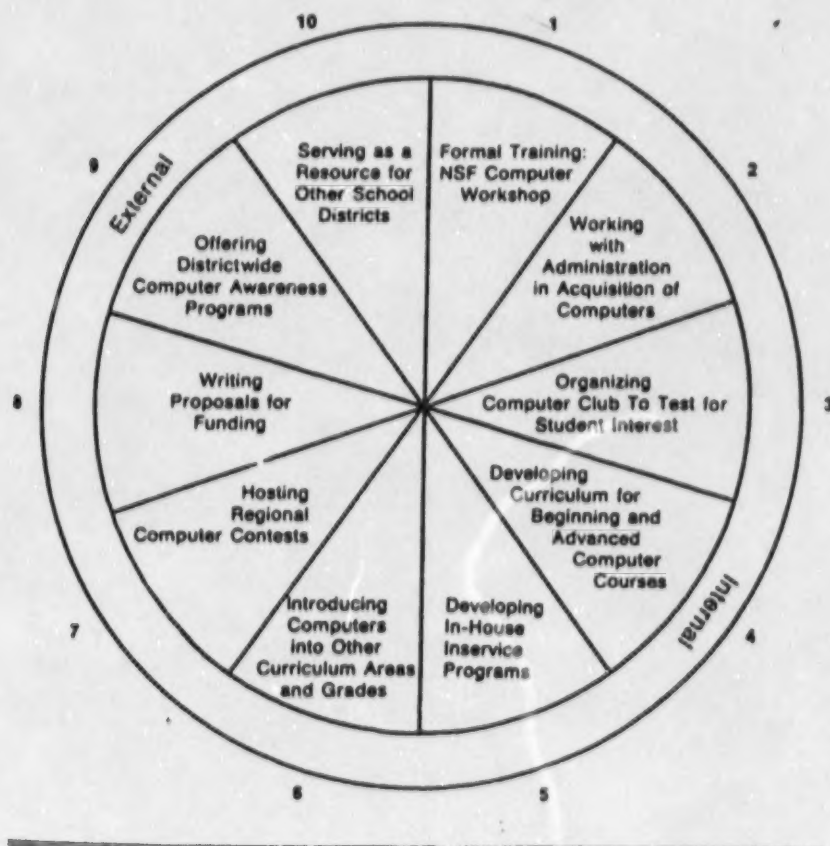
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2
APPENDIX

APPENDIX A

Illustration of Implementation Plan



Source: Guse:13

APPENDIX B

Table 1

Data on Program Use

<i>Program</i>	<i>Number of Known Users</i>	
	<i>Total</i>	<i>Attempting More Than One Problem*</i>
1	57	51
2	69	50
3	72	26
4	41	14
5	15	3
6	26	9

*At the same or different interactions.

Table 2

Responses from 259 Non-Users of CAI Programs*

<i>Reasons for Not Doing a Program</i>	
Did not know about them	9
Needed no help	66
Obtained help from teaching assistant	155
Obtained help from other students	159
Did not like working on the computer	93
Did not have time	125
Programs were not required	38
Programs did not cover topics needed	46

*Students could check any or all reasons.

Source: Cavin, Cavin, and Lagowski:44

APPENDIX C

Table 1
Impact of Instructional Aids
on Examination Scores

Instructional Aid	Average Examination Scores		
	Exam 1* (n=125)	Exam 2** (n=115)	Exam 3*** (n=118)
CAI	40.2	45.7	59.0
Study Guide	38.0	41.8	53.1
Both	38.5	43.7	54.8
Neither	<u>35.9</u>	<u>41.7</u>	<u>54.8</u>
Overall	37.4	43.0	55.1

* CAI vs. Neither— $p < .01$
 CAI vs. Study Guide— $p < .05$

** CAI vs. Neither— $p < .01$
 CAI vs. Study Guide— $p < .01$

*** CAI vs. Neither— $p < .05$
 CAI vs. Study Guide— $p < .01$

Source: Skinner and Grimm:35

APPENDIX D

Table 1.—Means, Standard Deviations, and *F*-values for Three Groups on Four Types of Measurement Instruments

Groups	Measurement instrument							
	Hour quizzes		Homework		Term project		Final exam	
	$\bar{X}$	<i>s</i>	$\bar{X}$	<i>s</i>	$\bar{X}$	<i>s</i>	$\bar{X}$	<i>s</i>
LI	80.10	5.80	86.97	11.36	83.33	6.79	86.93	4.04
CAI	83.17	7.09	90.27	9.57	85.46	8.19	85.53	11.20
LCAI	85.66	7.15	89.66	7.21	85.66	6.79	92.13	3.96
<i>F</i>	9.92*		3.19		3.01		21.46*	

*Significant at the .01 level.

Table 2.—Cross Comparisons of Three Groups for LSD Test on Hour Quiz Scores

	LI	CAI	LCAI
	80.10	83.17	85.66
LI	80.10		
CAI	83.17	3.07*	
LCAI	85.66	5.56*	2.59**

LSD critical values = 1.94 at .05 level and 2.62 at .01 level

*Significant at .01 level.

**Significant at .05 level.

Table 3.—Cross Comparisons of Three Groups for LSD Test on Final Exam Scores

	LI	CAI	LCAI
	86.93	85.53	92.13
LI	86.93		
CAI	85.53	1.40	
LCAI	92.13	5.20*	6.60*

LSD critical values = 2.06 at .05 level and 2.78 at .01 level.

*Significant at .01 level.

Source: Tsai and Pohl, 1978:69-70

APPENDIX E

Table 1

Variables Addressed by CAI Research

RESEARCH	VARIABLES	Subject Matter	Type of CAI	Branching	Student Attitudes	Feedback	Individualization	CAI vs. TI	Time	Retention	Student Variables
Suppes & Morningstar (1969)		•	•					•			
Bitzer & Alpert (1970)		•						•	•	•	
Coulson, Estavano, Melaragno, & Silberman (1970)				•							
Mathis, Smith, & Hansen (1970)		•			•						•
Lewellen (1971)		•							•		
Allen (1972)		•						•	•		
Molnar (1972)									•		•
Vinsonhaler & Bass (1972)		•						•			
Koch (1973)		•	•								
Tait, Hartley, & Anderson (1974)						•					•
Kulhavy (1976)						•		•			
Okey & Mayer (1976)				•			•				•
Magidson (1977)				•	•	•	•				
Grimm (1978)				•		•					
Magidson (1978)		•			•		•	•			
Tsai & Pohl (1978)								•			
Rankin & Trepper (1978)						•					

Source: Dence:52

APPENDIX F

Study	Mode	Subject	Grade Level	Results *
Arnold	Drill & Practice	Arithmetic	3 - 6	+
Crawford	Drill & Practice	Arithmetic	7	+
Martin	Drill & Practice	Arithmetic	3 - 4	+
Scrivens	Drill & Practice	Arithmetic	3 - 6	+
Suppes	Drill & Practice	Arithmetic	2 - 6	+
Fletcher and Atkinson	Tutorial	Reading	1	+
Bitter	Problem Solving	Calculus	College	+
Culp	Simulation	Chemistry	College	+
Lagowski	Mixed	Chemistry	College	+

* In this and subsequent figures, a + indicates that the students involved in CAI achieved more than non CAI students. A - indicates that the CAI studies did less well, while an = indicates the same level of achievement.

Figure 1. Studies That Involved CAI as a Supplement to Traditional Instruction

Study	Mode	Subject	Grade Level	Results
Abramson	Drill & Practice	Arithmetic	2 - 8	+, = *
Street	Drill & Practice	Arithmetic	3 - 7	=
Wilson	Drill & Practice	English	4 - 5	+
Cole	Drill & Practice	General Math.	High School	+
Adams	Drill & Practice	German	College	+
Morrison	Drill & Practice	German	College	=
Atkinson	Tutorial	Reading	1	+
Morgan	Tutorial	Algebra	High School	+
Lorber	Tutorial	Tests & Measurement	College	+
Cropley	Tutorial	Fortran	College	=
Proctor	Tutorial	Curriculum	College	=
Johnson	Problem Solving	Mathematics	7 - 9	+
Katz	Problem Solving	Algebra	High School	+, - *
Wing	Simulation	Economics	6	+, - *
Lunetta	Simulation	Physics	High School	+
Culp	Simulation	Chemistry	College	+
Hollen	Simulation	Chemistry	College	=
Diamond	Mixed	Biology	7 - 10	+
Diamond	Mixed	Reading	7 - 10	=
Carterright	Mixed	Education	College	+

* These three studies produced mixed results.

Figure 2. Studies That Involved CAI as a Substitute for Traditional Instruction

Mode	Study	Subject	Grade Level	Results
Drill & Practice	Arnold	Arithmetic	3 - 6	+
	Martin	Arithmetic	3 - 4	+
	Scrivens	Arithmetic	3 - 6	+
	Suppes	Arithmetic	2 - 6	+
	Crawford	Arithmetic	7	+
	Gipson	Arithmetic	7	=, +
	Abramson	Arithmetic	2 - 8	=, +
	Street	Arithmetic	3 - 7	=
	Cole	Gen. Math.	High School	+
	Wilson	English	4 - 5	+
Tutorial	Adams	German	College	+
	Morrison	German	College	=
	Atkinson	Reading	Intermediate	+
	Fletcher and Suppes	Reading	Intermediate	+
	Morgan	Algebra	High School	+
	Cropley	Fortran	College	=
	Krupp	Computer Prog.	Adult	=
	Lorber	Testing	College	+
	Proctor	Curriculum	College	=
	Sango	Elections	Adult	=
Problem Solving	Johnson	Mathematics	7 - 9	=
	Katz	Algebra	High School	+, -
	Bitter	Calculus	College	+
Simulation	Wing	Economics	6	+, -
	Lunetta	Physics	High School	+
	Culp	Chemistry	College	+
	Culp and Castleberry	Chemistry	College	=
Mixed	Hollen	Chemistry	College	=
	Diamond	Biology	7 - 10	+
	Diamond	Reading	7 - 10	=
	Lagowski	Chemistry	College	+
	Carterright	Education	College	+

Figure 3. Effectiveness of CAI According to Mode

Source: Edwards et. al.:148-150

Study	Mode	Subject	Grade Level	Comparison	Results
Culp	Simulation	Chemistry	College	Tutoring	==
Morrison	Drill & Practice	German	College	Lang. Lab.	==
Street	Drill & Practice	Arithmetic	3 - 7	P.I., Films	==

Figure 4. Studies Comparing Effectiveness of CAI with Other Nontraditional Methods of Instruction.

Study	Mode	Subject	Grade Level	Results	
				Achievement	Time *
Keckler	Tutorial	Mathematics	College	==	-
Lorber	Tutorial	Testing	College	+	-
Proctor	Tutorial	Curriculum	College	+	-
Krupp	Tutorial	Computer Programming	Adult	==	-
Sango	Tutorial	Electronics	Adult	==	-
Wing	Simulation	Electronics	6	==	-
Lunetta	Simulation	Physics	High School	+	-
Hollen	Simulation	Chemistry	College	==	-
Cartwright	Mixed	Education	College	+	-

* A - indicates that less time was required by CAI students.

Figure 5. Studies That Separated the Time Required for Students to Learn Through CAI Compared with Other Methods of Instruction

Study	Mode	Subject	Grade Level	Results *
Wing	Simulation	Economics	8	-
Lunetta	Simulation	Physics	High School	-
Proctor	Tutorial	Curriculum	College	==

* A - indicates that the CAI students retained material less well than the non CAI students.

Figure 6. Studies That Compared Retention of Material Learned Through CAI with Retention of Material Learned Through Other Methods

Study	Mode	Subject	Grade Level	Results
Martin	Drill & Practice	Arithmetic	3 - 4	Low +
Suppes	Drill & Practice	Arithmetic	2 - 6	Low +

Figure 7. Studies That Compared the Effect of CAI on Students of Different Abilities

APPENDIX G

Figure 1
Studies Included in the Survey

Field	Identification of Study	Year	Grade(s)	Subjects	Length of Study	Test Used	Reference for Study
L a n g u a g e	¹ California East Palo Alto	1970	1	88	10 Mos.	Stanford Ach/ Metropolitan Readiness Test	Fletcher & Atkinson (1971)
	² Michigan Waterford Indicom	1969	4*	68	4 Mos.	Stanford Achievement	Wilson & Fitzgibbons (1970)
	³ New York Harcourt Brace	69-70	4, 5, 6	1800 (National Sample)	5 Mos.	Stanford Achievement	Harcourt Brace (1971)
M a t h e m a t i c s	¹ California	66-67	4-6**	182	9 Mos.	Stanford Achievement	Suppes and Morningstar (1969)
	² California	67-68	1-6	665	7 Mos.	Stanford Achievement	Suppes and Morningstar (1969)
	³ Mississippi	67-68	1-6	515	3 Mos.	Stanford Achievement	Suppes and Morningstar (1969)
	⁴ New York	68-69	2-6	3000	5 Mos.	Metropolitan Achievement	Weiner <i>et al.</i> (1969)
	⁵ New York	69-70	2-6	3534	10 Mos.	Metropolitan Achievement	Abramson <i>et al.</i> (1971)
	⁶ Waterford	68-69	3-6	391	9 Mos.	Kiwa Test of Basic Skills	Scrivens (1970)
	⁷ Waterford	69-70	2-6	335	9 Mos.	Stanford Achievement	Arnold (1970)

*Includes Grades 4 and 5, but primarily 4th.

**Two experiments were conducted together in California in 1966-67. Only one, however, is included in this report. The other study had a confounding variable of two teachers in the control group giving their students an additional 28 minutes per day classroom instruction and practice in arithmetic.

Source: Vinsonhaler and Bass:31-32

Language Arts Results. Difference in Gain Scores for Groups Receiving CAI and Traditional Instruction Versus Those Receiving Traditional Instruction Only

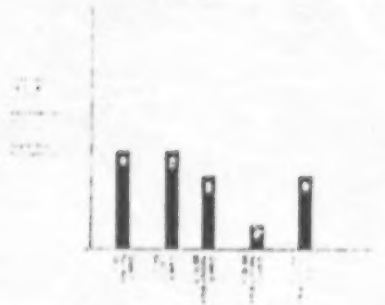


Figure 3

Mathematics Results. Difference in Gain Scores for Groups Receiving CAI and Traditional Instruction Versus Those Receiving Traditional Instruction Only

